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An external cavity klystron vacuum tube has a ceramic cylindrical wall surrounded by an external cavity within which is an output probe. The cylindrical wall section 1 is sealed at its ends to other components of the tube to enable the interior to be evacuated by sealing means such as to avoid a sharp edge projecting inwardly towards the interior of the cavity.

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(57) An external cavity klystron vacuum tube has a ceramic cylindrical wall surrounded by an external cavity within which is an output probe. The cylindrical wall section 1 is sealed at its ends to other components of the tube – to enable the interior to be evacuated – by sealing means such as to avoid a sharp edge projecting inwardly towards the interior of the cavity.

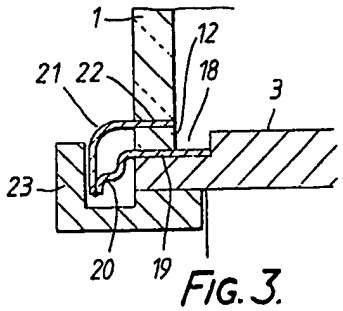

FIG. 3.

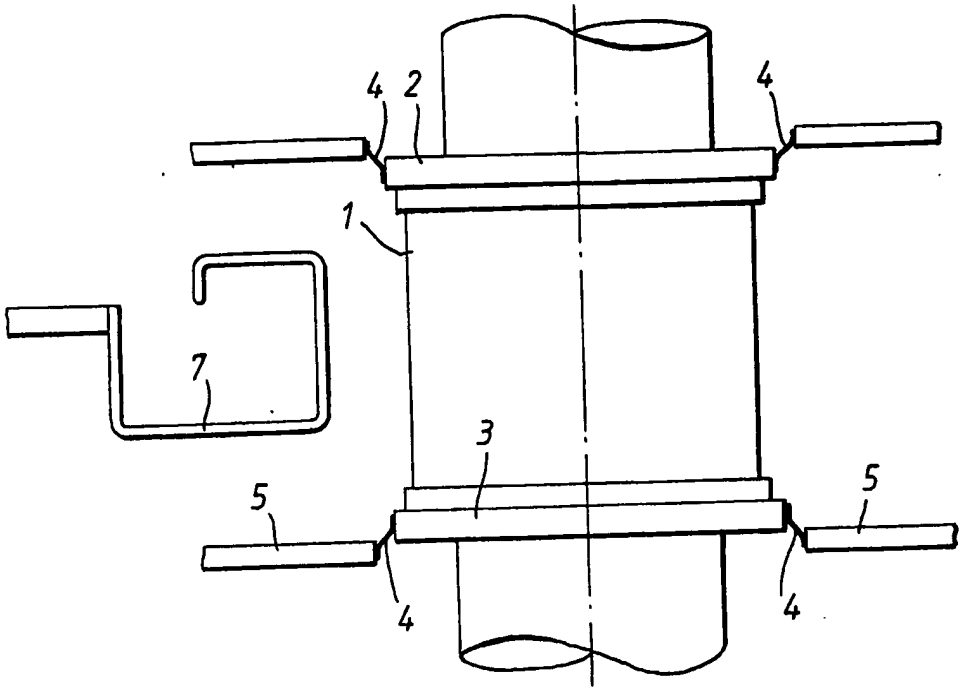

FIG. 1.

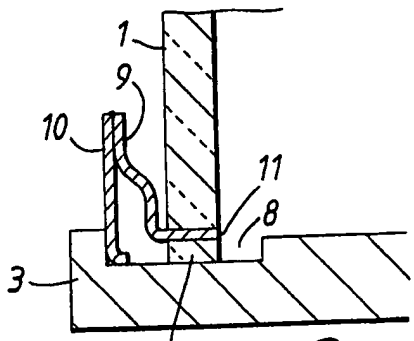

FIG. 2.

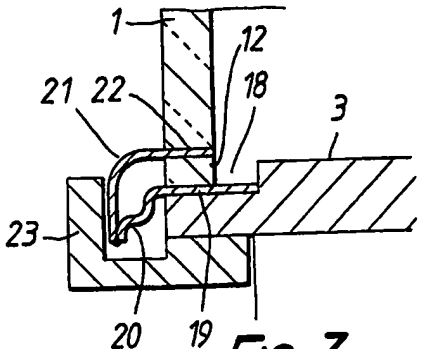

FIG. 3.

SPECIFICATION

Improvements in or relating to klystron vacuum tubes

This invention relates to klystron vacuum tubes and in particular to so called external cavity klystron vacuum tubes.

Part of a typical external cavity klystron vacuum tube arrangement as at present known is illustrated in Figure 1.

Referring to Figure 1 the tube comprises a vacuum wall section 1 in the form of a dielectric cylinder transparent to electro-magnetic radiation. This forms a window through which power is effectively transmitted. The cylindrical section 1 has, at either end, cylindrical copper annuli 2,3 which are shaped to receive the ends of the cylindrical wall member 1 and provide, by portions of increased diameter, contact for spring fingers 4 attached to the inner rims of a box member 5 surrounding the cylindrical wall 1 and forming the external cavity. In order to adjust the resonant frequency of the external cavity, a pair of moveable tuning plungers (extending at right angles to the plane of the paper and not shown) is provided, one one each side of the cylindrical wall member 1. To the left (as shown) of the cylindrical wall member 1 is a coupling loop 7, adjustable by rotation, by which output power is coupled to an external transmission line and aerial (not shown).

Particular attention should be given to the method of forming the vacuum seal between the cylindrical wall member 1 and the copper annuli 2,3. Since the cylindrical wall member 1 is normally of a high purity alumina or beryllia ceramic consistent with its function as a window, there will be observed a differential expansion between the cylindrical member 1 and the copper annuli 2,3. The coefficient of expansion of the material of the cylindrical wall member 1 is very much less than that of copper.

In order to accommodate for this differential expansion the joint between the cylindrical wall member 1 and each of the copper annuli 2,3 is normally as shown in more detail in Figure 2.

Referring to Figure 2 it will be seen that the cylindrical wall member 1 is located within a recess 8 in the copper annulus 3 (with a similar arrangement at the other end of the member 1). Use is made of an inner cylindrical flare 9 and an outer cylindrical flare 10. Inner flare 9 is brazed at one end 11 between the end of the ceramic wall member 1 and a ceramic balance ring member 12. The outer flare member 10 is brazed to the outermost wall of the recess 8 in the copper annulus 3. Finally the vacuum seal is completed by welding inner flare member 9 to outer flare member 10.

The whole construction forms a vacuum joint with the balance ring 12 pressing against the copper disc 3 and taking up the axial thrust due to the external pressure when the tube is under vacuum. In addition the balance ring 12 forms a sliding abutment with the base of the recess 8 accommodating for differential expansion between the cylindrical wall member 1 and the copper disc 3.

It has been found that a klystron constructed as described with reference to Figures 1 and 2 suffers from a serious defect. The output cavity 5 operates at the highest power level and the peak radio frequency voltage across the cavity is approximately the same as the operating voltage of the klystron, typically between 20 and 26kV for a high power television klystron. It has been found that arcing sometimes occurs in the cavity which not only can cause puncturing of the seal provided by the flares 9 and 10 but also, of course, interruption of operation if, as is commonly the case, an arc detector is introduced which removes the r.f drive from the klystron upon the detection of an arc.

The present invention seeks to provide an improved construction in which the aforementioned problem is mitigated.

According to this invention an external cavity klystron vacuum tube is provided including a cylindrical section of wall transparent to electro-magnetic radiation and provided to be surrounded by an external resonant cavity, at least one end of said cylindrical wall section being closed by a copper annulus which is stepped at its outer periphery, the inner rim of a flexible ring being secured to the base of said step whilst the outer rim thereof is turned over the outer edge of said copper annulus away from the interior of said cavity, the inner rim of another flexible ring is secured between the end of said cylindrical wall section and a balance ring member which bears upon the inner rim of said first flexible ring member, the outer rim of said second ring member is turned over the outer edge of said copper annulus away from the interior of said cavity and the outer edges of said two ring members are united. Normally with a construction as described above a collar is provided attached to said annulus and extending over the outer rim of said second ring member, the collars at each end of said wall section providing abutments for the walls forming said external cavity. Normally, as known *per se*, the walls of said external cavity terminate in spring fingers which, in the embodiment just described, bear upon said collars.

Normally said cylindrical wall member and said balance ring member are of ceramic material.

Normally said flexible rings are of cupro-nickel.

Normally the edges of the flexible rings are united by welding.

Normally the or each annulus closing an end of said cylindrical wall section is of copper.

The invention is further described with reference to Figure 3 of the accompanying drawings which illustrates an embodiment of a klystron vacuum tube in accordance with the present invention.

Figure 3 illustrates detail of the vacuum sealing means provided by the present invention in the way that Figure 2 illustrates the sealing means employed in the conventional tube and like references are used for like parts.

It will be seen that the embodiment of the invention illustrated is constructed so as to avoid having an edge between an inner and outer flare projecting inwardly towards the interior of the external cavity 5 and the coupling loop 7. Investigation suggested that it was this edge featuring in the

known construction illustrated in Figures 1 and 2 which tended to provoke arcing and thus the problems outlined hereinbefore. With the known construction of Figures 1 and 2 the electric field in the cavity tended to be concentrated at the welded edge of the inner and outer flares and high electric fields tended to be set up between the welded edge of the flares and the output loop 7 by means of which the power is coupled to an external transmission line and, subsequently, and aerial.

Referring to Figure 3, the seal is effected by means of a copper annulus 3 stepped at its outer periphery 18 and the inner rim 19 of a flexible cupro-nickel ring 20 is brazed to the base of the step to form a seating for the balance ring 12. The outer periphery of an annular ring 13 of cupro-nickel is turned down (as viewed) over the edge of annulus 3 and away from the interior of the external cavity 5. A thin cupro-nickel ring 21 has its inner rim 22 secured by brazing between the cylindrical wall member 1 and the balance ring 12. The outer rim of the ring 21 is also turned down (as viewed) over the edge of annulus 3 away from the interior of the external cavity 5 to meet the external periphery of the ring 20. The edge thus formed is welded to complete the required vacuum joint. To provide a suitable contact for the spring fingers 4 of the box section forming the cavity 1 (which should not bear on the surface of the ring 21 because of the risk of burning at the finger contact and consequent puncturing of the ring), a copper collar 23 is fitted around the sealing ring 21. Copper collar 23 is fitted either by means of a screw thread or it is soldered to the underside (as viewed) of the copper annulus 3.

The construction at the other end (not shown) of the cavity is similar.

CLAIMS

1. An external cavity klystron vacuum tube including a cylindrical section of wall transparent to electro-magnetic radiation and provided to be surrounded by an external resonant cavity, and wherein at least one end of said cylindrical wall section is closed by a copper annulus which is stepped at its outer periphery, the inner rim of a flexible ring being secured to the base of said step whilst the outer rim thereof is turned over the outer edge of said copper annulus away from the interior of said cavity, the inner rim of another flexible ring is secured between the end of said cylindrical wall section and a balance ring member which bears upon the inner rim of said first flexible ring member, the outer rim of said second ring member is turned over the outer edge of said copper annulus away from the interior of said cavity and the outer edges of said two ring members are united.

2. A tube as claimed in claim 1 and wherein a collar is provided attached to said annulus and extending over the outer rim of said second ring member, the collars at each end of said wall section providing abutments for the walls forming said external cavity.

3. A tube as claimed in claim 2 and wherein the walls of said external cavity terminate in spring fingers which bear upon said collars.

4. A tube as claimed in any of the preceding claims and wherein said cylindrical wall member and said balance ring member are of ceramic material.

5. A tube as claimed in any of the preceding claims and wherein said flexible rings are of cupro-nickel.

6. A tube as claimed in claim 1, 2 or 3 and wherein the edges of said two flexible rings are united by welding.

7. A tube as claimed in any of the preceding claims and wherein the or each annulus closing an end of said cylindrical wall section is of copper.

8. An external cavity klystron vacuum tube substantially as herein described with reference to Figure 2 of the accompanying drawings.

Amendments to the claims have been filed, and have the following effect:-

(a) Claim 1 above has been textually amended.

(b) New or textually amended claims have been filed as follows :-

1. An external cavity klystron vacuum tube including a cylindrical section of wall transparent to electro-magnetic radiation and provided to be surrounded by an external resonant cavity, and wherein at least one end of said cylindrical wall section is closed by an annulus which is stepped at its outer periphery, the inner rim of a flexible ring being secured to the base of said step whilst the outer rim thereof is turned over the outer edge of said annulus away from the interior of said cavity, the inner rim of another flexible ring is secured between the end of said cylindrical wall section and a balance ring member which bears upon the inner rim of said first flexible ring member, the outer rim of said second ring member is turned over the outer edge of said annulus away from the interior of said cavity and the outer edges of said two ring members are united.

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